REPORT OF THE NATURAL GAS SUPERVISOR.

LETTER OF TRANSMITTAL.

OFFICE OF NATURAL GAS SUPERVISOR,
KOKOMO, IND., January 11, 1897.

SIR—I herewith transmit to you my second annual report, the same being the fifth annual report from this department. It is made in obedience to section 7,504 of the Revised Statutes of the State of Indiana, and is for the year ending December 31, 1896.

The purpose of the annual reports from this department, as defined by law, and an outline of this report, are given in the introductory chapter.

Again I acknowledge the cordial support that I have received from you while I have had charge of this department, and, thanking you for the same, I respectfully submit this report and remain,

Yours sincerely,

PROF. W. S. BLATCHLEY,
State Geologist.

J. C. LEACH,
State Natural Gas Supervisor.

INTRODUCTORY.

The duties of the State Natural Gas Supervisor, as defined by sections 7504–5 of the Revised Statutes of the State of Indiana, may be briefly summarized as follows:

1. To make a personal inspection, as far as it is practicable, of all the natural gas property in the State, including wells, pipe lines, machinery, etc., giving special attention to the precautions taken to insure the health and safety of workmen engaged in opening gas wells and laying mains and pipes and those who use natural gas for any purpose.

2. To collect and tabulate certain statistics regarding the geological formation, gas wells, pipe lines and manufacturing industries of the gas belt.

3. To see that all the provisions of the law pertaining to the drilling of wells and the piping and consumption of natural gas are faithfully carried out and that the penalties for the violations of the same are enforced.

4. To make an annual report to the State Geologist.

As with the duties attached to other departments of this class, the different items specified in the above summary are not alike important, and the performance of the same does not prove equally beneficial to the State; and unlike other departments, the relative importance of each class of work and the time necessary to perform the same changes with time, the age and condition of the field largely governing. The value of natural gas as a heat producing power, the past history of this gas field and its present condition certainly emphasize the fact that everything possible should be done to husband the present supply of gas. There are many ways that this can be done, and it has been to this end that my work has been directed this year. Most of my time has been spent in the field, and the information given and recommendations made are the results of observation and experiments, and not hearsay.

A brief statement of the work accomplished will be given in its appropriate connection.

The protection of the consumer and those engaged in any capacity in the natural gas industry from danger caused by carelessness or a lack of knowledge of proper methods of controlling and using this gaseous fuel seems to be the primary purpose of the law outlined in the first part of

the above summary. True as this may be, however, the knowledge that this department gains, incidental to the inspection, of the condition of the field, the manner of use, and cause and extent of waste is one of the desirable as well as profitable results. It enables the supervisor to give those interested in the natural gas and manufacturing industries accurate information concerning the ever changing condition of the field and affords an opportunity to suggest economical methods of use when necessary.

The progress of the field is watched with much interest by all classes, especially those engaged in manufacturing. During the early history of natural gas in this State, but little attention was given to the condition of the field. Scientists were busy investigating phenomena attending its discovery and utilization, while residents of all occupations were busy advertising its merits. The lack of accurate and reliable information, on the part of a majority of the consumers, regarding the generation and supply of this valuable fuel, rather than a lack of knowledge of its value, or a due appreciation of the same, accounts largely for the great waste of this fuel in the past. Those who have studied the scientific phases of the question; who are familiar with the history of other gas fields and who have watched the progress of this field from year to year, know that none of these warrant waste or even extravagant use. For a number of years, to the consumer, every indication pointed to an inexhaustible supply of gas; but when the first wells began to show signs of exhaustion, attention was directed to the cause, and as a result a change was soon wrought in the popular ideas concerning these questions. The accepted theories accounting for the generation, storage, pressure, etc., of natural gas are reasonable, and these, if understood, with a knowledge of the progress of the field, will do much to prevent the prodigal use of gas that has characterized this field in the past. Then, as unfamiliar conditions arise from time to time, they should be noted, studied in the light of science and experience, and intelligently met, or we shall fail to get the full value of this reservoir of gaseous fuel that nature has given to us. For reasons that are patent, considerable space is given to this subject in this report. I know that the careful reader will learn the true condition of the field, and I trust that it will not only be of interest to those interested in this valuable industry, but will prove beneficial as well. Reference to the other subjects embraced in this part of the summary is made in the body of the report.

Full and complete statistics regarding the manufacturing industries of the State are given in the annual reports of the Bureau of Statistics and are not repeated here.

For information regarding the geological formation of the State, the reader is referred to the annual reports of the State Geologist.

The fact that many of the questions relating to the scientific phase of the subject are no longer disputed by those who have both a practical and theoretical knowledge of the same; that reasonable theories, accounting for the origin, accumulation, pressure, etc., of natural gas have long ago been discussed and accepted by the leading scientists of the country, makes a discussion of the subject at this date, a reiteration of what has been said and of very little interest to the public. It has been suggested that these conclusions are old; that they have not been added to recently. True, but is that any reason why they should be abandoned or why they are not true? Are these the only theories in the world that are old, that have not been proven false by new discoveries? Concerning natural gas, we know its nature; as to its origin all geologists agree; that the supply will finally become exhausted is not questioned any more; how long it will last is the question that has not been answered to the satisfaction of all, nor will it be. In the Twentieth Annual Report of the Department of Geology and Natural Resources, brief statements of the views accepted by the leading geologists of the country regarding the origin, accumulation and pressure of natural gas are given. All generalizations and discussions in this report are based upon the data and conclusion there given.

What the future history of natural gas in Indiana will be, depends largely upon how gas is used in the future; upon conditions attending the use of this fuel that are under the control of the gas companies and consumers. Reference will be made to this subject in a subsequent chapter.

The natural gas law of the State seeks to regulate the use and prevent the waste of natural gas; to protect from danger those who use gas for any purpose, by making it the duty of the Natural Gas Supervisor to inspect the pipe lines, regulators, etc., from time to time; to see that the proper precautions are taken to insure the health and safety of those who use it, and to condemn any line or portions of lines that are unsafe. During the early history of the field this law encountered much opposition, especially by the residents of the gas belt owning their territory and wells. Those opposed to the law contended that it abridged their rights as citizens; that natural gas is property and as such the owner has a right to use it as he desires. In opposition to this the State claims that the welfare and prosperity of the public overshadows the desire, or even good of the individual, and that the general good of all demands that a reasonable economy be practiced in the use of this gaseous fuel and if necessary, the enforcement of law to attain this is but a judicious exercise of the police powers of the State. Most opposition has been directed toward what is known as the "flambeau law," the constitutionality of which is questioned. A suit brought in Blackford County to enforce this law is now before the Supreme Court, and an early decision is expected.

I am glad to know that during the past year a great change has been wrought in the public mind on this subject. The purpose of the law is better understood and its necessity and value appreciated. The law concerning the sinking, safety, maintenance, use and operation of natural gas and oil wells and the inspection and condemnation of unsafe pipe lines and natural gas machinery is being executed and has the support of all interested.

Referring to the annual reports of this department, it has not been found possible in the past, both for want of time and space to report on all subjects indicated above in any one annual report. This would not be profitable, even if practicable. Of necessity, a large part of the Supervisor's time must be spent in the field; hence a report from this department can be little more than a record of the field work. However, in this report I have endeavored to give some space to the most important of those subjects demanding attention at present. During the year I have received a large number of letters requesting information and advice. A careful reading of this report will, I trust, render more intelligent the answers that I have given.

ACKNOWLEDGMENTS.

I take this opportunity to express my indebtedness to all who have rendered me assistance in my work. Wherever my official duties have brought me in contact with owner or managers of gas plants, manufacturers, farmers or drillers, they have been uniform in their kindness to me, giving me all the information possible and assistance desired. Largely on account of this, my work during the past year has been pleasant and I trust profitable to the natural gas industry, and consequently to the manufacturing, commercial and other industries of the gas belt.

NATURAL GAS.

In the history of civilization nothing is more interesting than the progress mankind has made toward the subjugation and utilization of the forces of nature for human welfare, and in recent years the most important fact in this onward movement is the discovery of natural gas in commercially valuable quantities and its use as a fuel. While its presence was known and its power utilized in prehistoric time it has only been within the last few years that it has been used so extensively as to modify the course of human progress. Though the use of it is limited to a comparatively small area, its influence is felt far and wide. As a heat-producing power, it possesses extraordinary value, and its utilization as a

fuel has awakened a business activity within its own territory heretofore unknown. It can be used for almost all purposes for which any other fuel is used, and for cleanliness and convenience it is not surpassed.

Natural gas is a compound of carbon and hydrogen. Its principal constituent is marsh gas, which is composed of 75 parts, by weight, carbon and 25 parts hydrogen.

A brief description of the chemical constituents of Indiana natural gas was given in my last annual report, and is not repeated here, but for convenient reference the analysis is given.

*Composition of Natural Gas (Haynes).**

Carbon	70.25
Hydrogen	21.45
Sulphuretted hydrogen	.17
Carbonic acid	.02
Nitrogen (by difference)	7.93
Total	100.00

NATURAL GAS ROCK.

While it is a fact that natural gas has been found in nearly every country and geological formation, and that its presence in various localities has been known for centuries, it is equally true that it is only in a few favored localities, where the textural and structural condition of the rock is favorable to its storage, that it has been found and used extensively as a fuel.

The Trenton limestone, a universal formation in this State and one of the most widespread on the continent, is both the source and the reservoir for natural gas in Indiana. "While it is true that the Trenton limestone is a universal formation in this State and is a reservoir for natural gas, it is equally true that these products occupy but a limited strata of this limestone and a comparatively small area of the State. The cause of this is found in the textural and structural conditions of the gas-producing rock.

"Trenton limestone is seldom a gas rock below sixty feet from the upper surface, the gas-producing stratum ranging from five to twenty feet thick. Observation and the analysis of this rock shows that its productiveness is due to its porosity. Wherever the Trenton limestone is a gas or oil rock, it is always substantially a pure dolomite, highly crystalline and of a sufficient porosity to contain large quantities of these hydrocarbons. Its storage capacity is much greater than that of sandstones. Outside of the gas area the conditions are different. There the limestone is nearly pure and non-porous The dolomitic change has not taken place.

* Twentieth Annual Report of Department of Geology and Natural Resources of State of Indiana, 1895, p. 401.

"From the above it is plain that the porosity of the Trenton limestone is due to its chemical composition, or at least connected with it. In the oil and gas area this limestone has been transformed in its upper beds, the carbonate of lime giving way in part to carbonate of magnesia."*

In the following analysis the difference in composition of a productive and non-productive rock is illustrated. At Muncie, Indiana, the limestone contains 38.11 per cent. of carbonate of magnesia, and is a productive gas rock, while at Vernon, Indiana, it contains but a trace of carbonate of magnesia, and is a barren rock.

Composition of Trenton Limestone.†

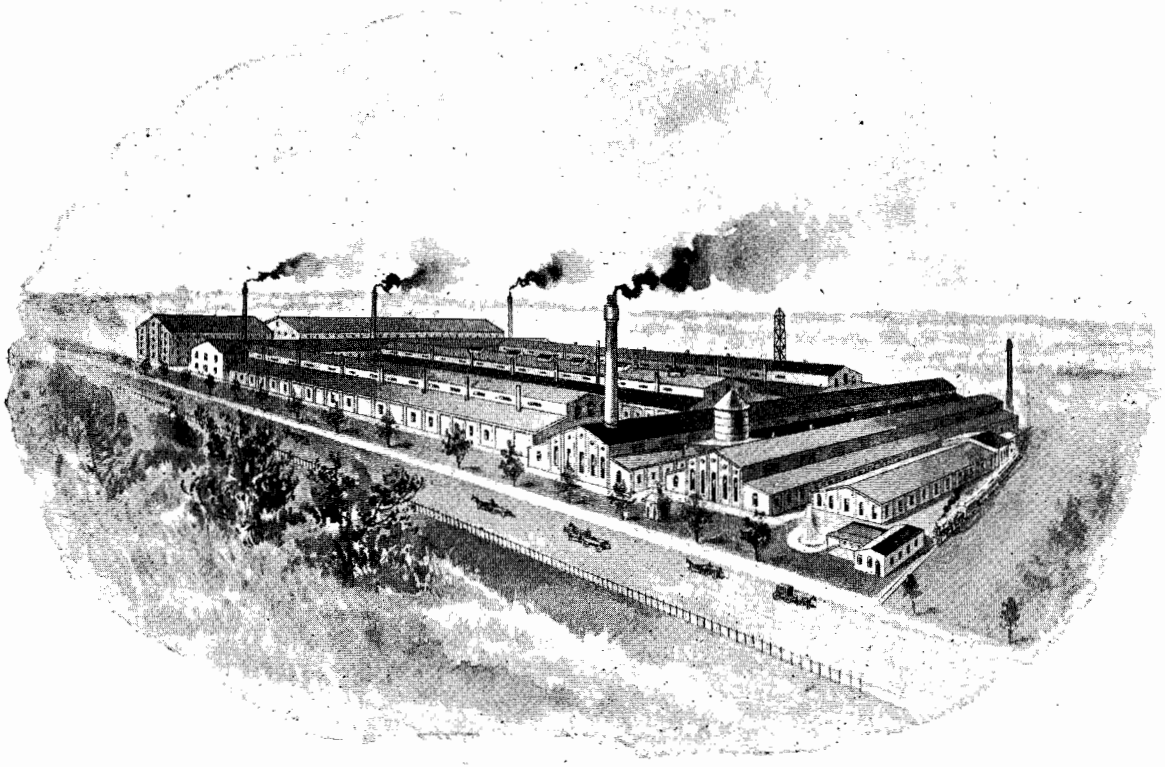
	Muncie.	Vernon.
Carbonate of lime	51.96	85.56
Carbonate of magnesia	38.11	Trace.
Alumina and oxide of iron	3.72	.60
Siliceous residue	3.30	8.00
	97.07	94.16

THE DISCOVERY AND UTILIZATION OF NATURAL GAS.

The story of the discovery of natural gas, and the exploration that followed, with the attendant success and failure of the prospectors; the approximate location of the gas area, and its development since, have been chronicled in the annual reports from this Department, and are open history. The advantages possessed by this fuel were soon demonstrated, and fuel users were not slow to adopt it. When it became known that the Indiana natural gas field was the largest and, from all indications, the most stable of any yet discovered, the manufacturing industry of this section of the State began to grow with a rapidity unknown in the past. Old factories were enlarged, new ones built, and ere long the gas belt was the manufacturing center of the State. In 1886, when natural gas was discovered, this section of the State was devoted almost entirely to agriculture. Besides the customary flouring and saw mills, the factories were few and confined almost exclusively to the manufacture of wooden wares. To-day nearly all classes of manufacturing industries are represented. Nor are these factories temporary affairs. A majority are large and well built, employing from 300 to 1,000 people.

*Twentieth Annual Report of the Dept. of Geology and Natural Resources of the State of Indiana; 1895, p. 383.

†Eighth Annual Rept. U. S. Geological Survey, 1889.



Pittsburgh Plate Glass Factory, No. 8, Kokomo, Ind. Natural gas for fuel. Similar factories at Elwood and Alexandria, Madison County, Ind.

The glass industry in all its departments has increased most rapidly since the discovery of gas, caused by the perfect adaptation of this fuel to its manufacture and the superiority of the manufactured product. Nor are the tin and iron industries far behind. The tin, though a comparatively new industry, is one of the most prosperous in the gas belt. The large towns have not been the only gainers by the growth of the manufacturing industry. Factories locating in the gas belt considered transportation facilities next after cheap fuel, and many small towns being advantageously situated in regard to both, have experienced a growth not excelled by the cities. Manufacturers, however, are not the only class of people being benefited by natural gas. All classes, the merchant, farmer and laborer are its beneficiaries. Not a few farmers are receiving annually gas well rentals equal to the annual rental value of their land for farming purposes. The hundreds of wells that are being drilled and the miles of pipe-line that are being laid annually, with the labor that is necessary to properly care for the gas plants of the State, furnish work for a large number of men.

The discovery and utilization of natural gas has added materially to the wealth of the State. The natural gas property, which includes wells, pipe-lines, pumping stations, etc., is assessed for taxation at near $5,500,000. As pipe-line extensions are made and pumping stations erected this sum will be increased. The life that has been given to the manufacturing industry in this section on account of natural gas has added largely to the population and wealth of the State. The factory property alone is listed at nearly $6,000,000, and this is a small per cent. of the increase in wealth since the discovery of gas. In 1887 the total assessed valuation of the property in Madison County* was $9,837,595, which yielded a tax amounting to $168,339; in 1895 the former had increased to $26,994,775 and the latter to $397,569. This is a total increase of wealth in eight years of $17,157,180, or, exclusive of gas property and factories, $13,917,180.

The increase on account of gas property and factories is seen to be about one-fifth of the total increase. The lack of space forbids further details on this subject, but it is reasonable to believe that the same ratio holds throughout the field, with the possible exception of the outer zone.

Enough has been said to show the advance that this section of the State has made in material prosperity since the discovery of natural gas. Briefly, that discovery has added materially to the wealth of the State; it has stimulated the manufacturing industry, which in turn has added largely to our population and wealth; it has increased the farmer's income; it has reduced the fuel expense, and furnished profitable employment for thousands of men. In a word, it is a blessing to all, a

*Madison County is here cited because, through the courtesy of the county officials and the Board of Review, I was able to get the necessary data somewhat in detail.

proper appreciation of which would, I believe, materially extend its life.

In 1883 natural gas began to be used extensively as a fuel in Pittsburgh. Soon afterwards, explorations extending westward through Ohio and Indiana began in earnest. Gas was found in the Trenton limestone at Findlay, Ohio, in 1884; at Portland, Jay County, Indiana, March 14, 1886. This was the first productive well drilled in Indiana of which we have any record. Though the flow of gas was small, it stimulated the exploration in more productive territory. When it was known that the Trenton limestone in this section of the State was a gas-producing rock, companies were organized and scores of drills started. Though many failures were recorded, some were successful, and the result was that while the prospectors lost much capital and labor, the public was the gainer, for the gas belt was located and the knowledge gained from the records of the many wells drilled in all parts of the field are invaluable from a scientific standpoint. The people were not slow to learn the advantages possessed by the new fuel. The first wells were drilled at county seats, which were naturally the larger towns. Soon, however, companies were organized to supply the small towns, "farmer companies" to supply the rural districts, and every resident of the field had an opportunity to use gas. At the beginning only enough wells were drilled to supply domestic consumption, but this condition was soon changed by the location of factories and the extension of pipe lines to a number of the cities outside the gas belt. The factories, which are the large consumers of natural gas, very materially increased the draught on the territory in the vicinity of the cities and towns. Those factories that were large fuel consumers were naturally the first to locate in the gas belt, and statistics show that they are largely in the majority now. Full and complete information on the subject can be found in the Annual Reports of the Bureau of Statistics and under the head of "Manufacturing Industries" in the Report of the Eleventh Census, 1890.

PIPE-LINES.

Like the factories, pipe-line cities draw their supply from a limited territory, extending their lines from time to time as the old territory shows signs of exhaustion. The following Indiana cities, located outside of the belt, are drawing on this field for their fuel supply, to wit:

Bluffton, Connersville, Crawfordsville, Decatur, Frankfort, Ft. Wayne, Huntington, Indianapolis, Lafayette, Lebanon, Logansport, Peru, Richmond, Shelbyville, Union City, Warren and Wabash. In addition, natural gas is piped from this field to Chicago, Ill., and Buckland, Cold Water, Cridersville, Dayton, Fort Recovery, Hume, Lima, New Knoxville, Piqua, Springfield, St. Marys, Tippecanoe, Troy and Wapakoneta, O. For Chicago, the Ohio cities and towns and Indianapolis, Logansport,

Lafayette and Richmond, the field pressure is re-enforced by means of compressors or pumps. With these the pressure can be raised to 300 pounds* to the square inch, which in most cases insures satisfactory service.

PRODUCTION.

It is impossible to give an accurate statement of the annual production of this field, of value of gas consumed or of number of domestic consumers. The reasons are obvious. Wells can be measured and the production ascertained for a certain period. This, however, is only the rate of production for the time the measurements were taken, for the production of a well varies, and a fair estimate of it for a given time does not indicate what it will be an hour later. It is thus seen that a measurement of all the wells would give but an approximate estimate of their annual production It is just as difficult to ascertain the consumption of natural gas in cubic feet. The methods of consumption are such that the only approximately satisfactory way of obtaining the value of the gas consumed is to ascertain the value of the fuel displaced by it. This is the basis of calculation used by the U. S. Geological Survey. From the most reliable information obtainable the Survey gives the following:[1]

"The total value of natural gas consumed in Indiana in 1895 was $5,203,200, as compared with $5,347,000 in 1894, a very slight decrease."

In the following table will be found a statement of the value of natural gas consumed in Indiana from 1886 to 1895:

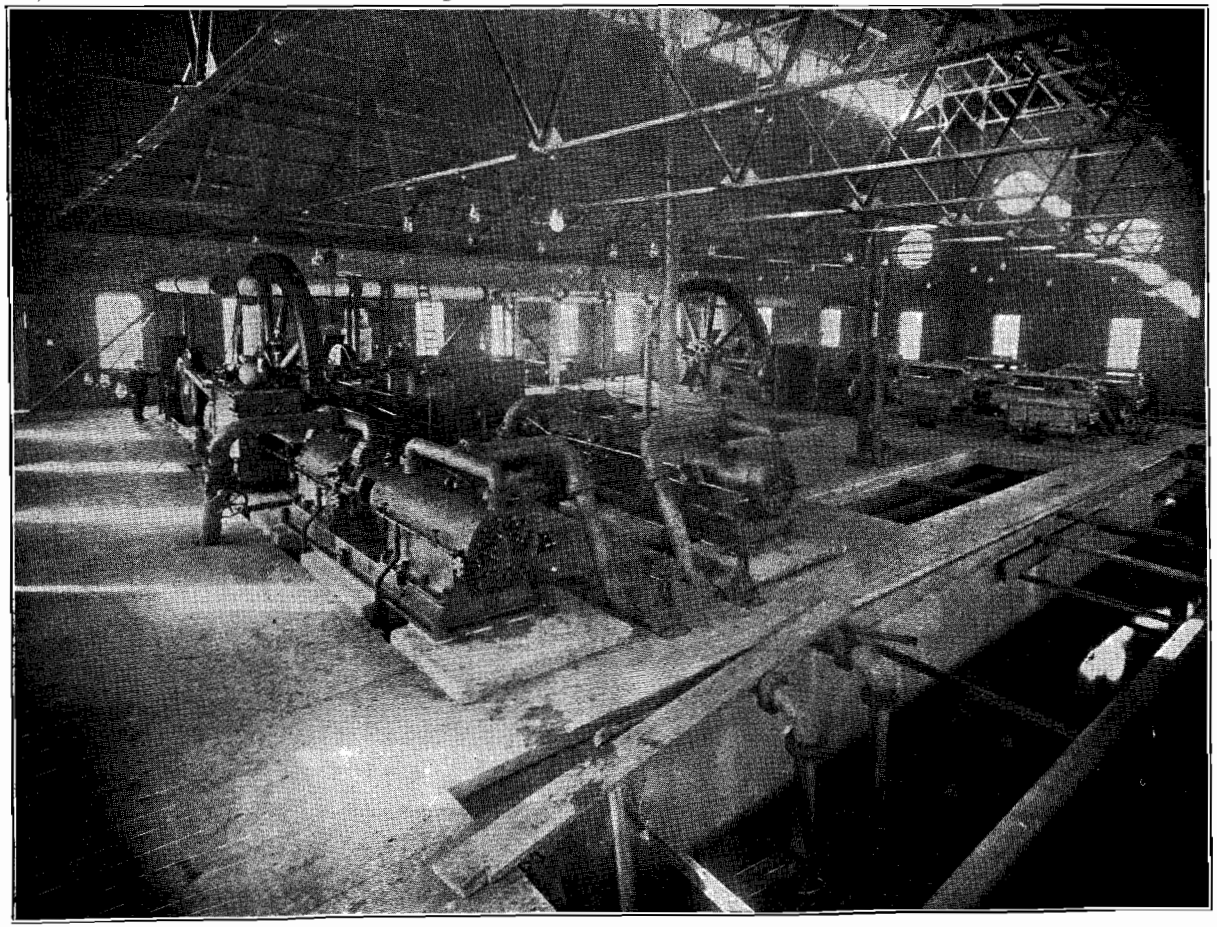
Value of Natural Gas Consumed in Indiana from 1886 to 1895.[2]

Year.	Value of Gas Consumed.	Year.	Value of Gas Consumed.
1886	$300,000	1891	$3,942,500
1887	600,000	1892	4,716,000
1888	1,320,000	1893	5,718,000
1889	2,075,702	1894	5,437,000
1890	2,302,500	1895	5,203,200

*An act passed by the General Assembly of 1891 (Acts 1891, p. 89), declares it to be unlawful to transport gas through pipes at a pressure exceeding 300 pounds per square inch, or to use any device for pumping or any artificial process or appliance for the purpose, or that shall have the effect of increasing the natural flow of natural gas from any well, or increasing or maintaining the flow of natural gas through the pipes used for conveying and transporting the gas. In the case of *Jamieson* v. *The Indiana Natural Gas and Oil Co. et al.*, 128 Indiana 555, the Supreme Court held that artificial pressure may be applied provided it does not exceed 300 pounds to the square inch.

1. The amount of work assigned to this department precludes any time given to experiments and calculations along this line.

2. Seventeenth Annual Report U. S. Geol. Surv., 1895-96.



MANUFACTURERS' NATURAL GAS COMPANY'S PUMPING STATION.
Interior View. Located near Frankton, Madison County, Ind.

Knowing the difficulty in obtaining full and complete information regarding these subjects, the above statements can not be more than approximate. If the reader will consider the large territory that is privileged to use this fuel for both domestic and manufacturing purposes, and that the factories are the large consumers, not a few of them requiring wells sufficient to supply towns of 3,000 inhabitants, he will gain an idea of the draught that is being made on the Indiana natural gas field.

PRESSURE.[1]

When speaking of the conditions of a natural gas field, reference is usually made to its rock pressure, many believing that accordingly as this is high or low, so is the productiveness of the field great or small. This is a mistake. While a decrease in the rock pressure indicates a general diminution in the supply, the closed pressure of a well does not indicate the volume of flow or the permanence of the supply. I have measured wells this year that registered a rock pressure of 210 pounds, and when allowed to flow unobstructed into the air did not produce one-half million cubic feet of gas in twenty-four hours, while other wells with a lower rock pressure discharged three times that amount of gas in the same time. The true index of the volume of flow of a well is the open flow pressure. True, when the rock pressure is considered with the time required to gain it, and compared with the same items of a well of known volume, an approximate estimate can be made. It is obvious that a well that shows a closed pressure of 100, 200 or 250 pounds in a minute is more productive than one that requires five or ten minutes to gain the same pressure.

From observed conditions of pressure and volume of flow in this field, the following conditions are found to be present: (1) A lack of uniformity in rock pressure; (2) a lack of uniformity in volume of flow; (3) a medium rock pressure and a small flow of gas; (4) a medium rock pressure and a productive well.

When a well is closed it becomes a part of the main reservoir, and if all the wells in the field were closed, each in time would show the same rock pressure, and the first condition given above would not exist. It does, however, and the reasons are found in the difference in the draught on certain areas, and in the texture of the rock. A gas well has reached its maximum rock pressure when the gas in it is of the same density as that in the rock. The time required to obtain this varies in different localities. When the Trenton limestone is very porous, and the gas passes freely through it into the well, the maximum rock pressure is reached

1. For cause of natural gas pressure, etc., see Twentieth Annual Report of the Department of Geology and Natural Resources of the State of Indiana, 1894, pp. 384-85; also this report, pp. 44-45.

quickly when the well is closed. When opened into the line the rock pressure lowers but little, and the volume of flow is large, but if the conditions are changed, a change in the result will follow. That is to say, if there is a lack of porosity in the rock and the gas passes through it slowly, it requires time for it to reach the maximum rock pressure and the capacity of the well is small.

It is plain, I think, that when the draught on the well is so great that the gas does not attain the density of that in the rock before it is discharged that the rock pressure will be low, and that when the porosity of the rock permits it to pass freely to the bore, thereby permitting a heavy draught without materially lowering the density of the gas, that the rock pressure will be nearer the normal pressure of the field. Then, on account of the difference in the porosity of the rock, one well may produce but little gas, and another well in the same locality be of greater capacity; yet, whether large or small, they will, if closed, eventually reach the same rock pressure. This may require days, for, on account of the small difference in the pressure of different sections of the field, it will equalize very slowly. A well that will produce 6,000,000 cubic feet of gas in 24 hours shows no greater rock pressure than one that produces only 500,000 cubic feet, though the first reaches its maximum pressure in a few seconds, while the latter may require hours. Rock pressure does not indicate the productiveness of the field, or the condition of the supply.

Referring to this subject, Prof. Edward Orton says:* "The rock pressure of gas may perhaps be continued with little abatement of force until the end of the production of a field is near. The maintenance of pressure is no proof whatever of the maintenance of supply. The last thousand feet of gas come out from the gas-holder with as much force as the first thousand feet. In a field that contains both gas and oil, but in which the reservoir of these is differentiated, the first sign of approaching failure will be the invasion of either level by the contents of the division next below."

I have noted briefly some of the points of interest in the history of this field and outlined the conditions of the rock pressure, volume of flow, etc., that exist. With these in mind, we are better prepared to understand the present condition of the field.

CONDITION OF THE FIELD.

The Indiana natural gas field is in the eastern central part of the State and embraces the major part of seventeen counties. In shape it is an irregular obovate, its extreme length not exceeding 100 miles and its extreme width 70 miles. The original area contains about 2,500 square

* Eighth Annual Report of the U. S. Geological Survey, 1889, p. 598.

miles. As a whole, this is the most productive field that has yet been discovered. True, within the field an occasional "dry hole" is found. In such cases it usually happens that the rock in the vicinity of the well is too dense to permit the gas to pass through it. These barren areas are very limited, and in many cases productive wells have been obtained in close proximity to these failures.

By reason of the structural difference in the gas rock and the heavy draught on certain parts of the field, it can be divided into three divisions or zones, the basis of the divisions being development of territory, pressure and productiveness. This division does not take into consideration the narrow strip of territory extending south from a line running east and west through Carthage, Rush County, though southeast of this town is a fairly productive area. In the outer zone, which according to this division varies from five to fifteen miles in width, the gas rock, though productive at first, is, on account of its structural condition, its relation to the field and the long-continued and heavy draught that has been made on this part of the field, overrun with salt water. Many of the wells drilled during the early history of the field are practically worthless. Those wells that continue to produce gas and are attached to pipe-lines can only be used at periods of light consumption when a high line pressure is not required. Therein lies the danger to this territory, for it is not advisable to close wells showing signs of salt water for any length of time. There is a constant warfare between the pressure of gas and the salt water, and when the gas is held in the rock for any length of time the water accumulates in the well and will in a short time overbalance the pressure of the gas, hermetically sealing it in the rock. Wells like the above have been relieved for a time by dropping a small pipe to the bottom of the well, and the pressure of the gas, while not strong enough to raise the column of water in two or three inch tubing, will raise it through a three-quarter inch pipe. By allowing the small pipe to remain open at intervals, governed by the amount of water, the well will in most cases continue to discharge gas, more than sufficient to pay the expense of retubing. The rock pressure of this part of the field varies from 75 to 200 pounds.

The middle zone, varying in width from ten to twenty-five miles, is the principal source of the fuel supply for the pipe-line cities at present. Some of the most productive wells of the field are found here, and notwithstanding the fact that nearly all the large pipe lines pass through this territory, it lacks much of being fully developed. Hundreds of acres of good territory await the drill. Probably a majority of the wells show signs of water, but its advance so far has not been sufficient to offer much resistance to the gas. In a number of instances separators have been placed at the wells, and drips on the lines to counteract the influence of water. Concerning these I can only say that any effort made to minimize

the evil influence of salt water is commendable. There are many devices designed to conduct the water from the bottom of the well, to separate the water and gas at the surface, and to catch the water that passes into the line. All have the same purpose in view, and under proper conditions show merit. Different conditions require different treatment, and meritorious devices frequently, through a lack of proper adjustment and care, fail to do the work for which they were designed. I desire to emphasize the fact here that natural gas plants need skillful, painstaking management. Not only the managers, but the men who care for the wells, pipe lines, etc., should understand the business in all its details.

While the decrease in the rock pressure during the past year throughout this area is universal, it has not been uniform. The gas in the Indiana field is entrapped in the Cincinnati arch, held there by a hydrostatic pressure equal to the weight of a column of water, the height of which is the difference in altitude between the surface of the water within the arch and the land surface of the catchment area. From this it is seen that prior to the tapping of the reservoir the gas pressure is uniform throughout the field. The lack of uniformity in pressure has been referred to in a previous section.

It was thought by those who have been watching the progress of this field that the decrease in pressure during the past year would be greater than the year previous. While the past history of the field warranted the forecast, the present condition does not fulfill it. The decrease in pressure in this part of the field during the past year is not greater than it was during the previous year, and in a few instances it is less. If pressure is governed to any extent by consumption, and it is, then the mild winter of 1895–6, the disposition on the part of the manufacturers to husband their fuel supply, and the general business depression which has affected the manufacturing industry so largely, accounts for the condition of the field. The inactivity in the natural gas industry, and the decrease in the number of wells drilled, is a consequence of the light consumption during the year. This part of the field is no exception to the general conditions found in all fields. Those areas most thoroughly developed, that contain most pipe-lines and wells, that supply the largest consumption, suffer the largest decrease in pressure. January 1, 1895, the rock pressure of this part of the field varied from 225 to 270 pounds, there being but a very few wells in and very near the large towns showing lower than the former. The average pressure of the zone was not far from 250 pounds. January 1, 1896, shows a pressure ranging from 200 to 250 pounds. While the decrease in pressure during the past year is as low as ten pounds in areas of light consumption, it has reached thirty pounds where the draught has been the heaviest. The measurements of wells in and near the large cities and towns are not considered in any of the data given.

The third zone, if it can be termed such, is the heart of the field; a region that has not been invaded by pipe lines of any considerable length. It embraces parts of Madison, Delaware and Grant Counties.* It contains, approximately, 400 square miles, and the wells that have been drilled testify to its productiveness. The upper and productive portion of the rock is free from salt water, and many wells drilled in 1887 are still producing gas. While the pressure is but little higher than that of the middle zone, it is more uniform. Recent tests show a rock pressure varying from 225 to 250 pounds. The fact that the consumption has been comparatively light during the past year has been conducive to the equalization of the field pressure, and a consequent heavy reduction of the pressure in the high pressure areas. I have said, in substance, that notwithstanding the fact that the rock pressure does not indicate the productiveness of a well, that any material reduction in it indicates a diminution in the supply. Therefore, in giving the condition of the field, I refer to it frequently. I know that it may convey a wrong impression in some instances, but it is the only way we can give the public an approximate idea of the condition of the supply of gas.

There are many erroneous ideas entertained regarding the rock pressure of this field. It is contended by some that it has not decreased a pound during the past ten years. Investigation proves that usually the fault is with the gauge used rather than an intentional exaggeration. In most cases cheap and inferior gauges are used, and, if correct when new, are soon unreliable. Gauges for this purpose should be protected from salt water or rough usage, and tested frequently to get correct results. The pressures given below are the averages of numerous tests made in each of the various localities reported, and were made with gauges made especially for the purpose and tested and corrected at frequent intervals. If there are any errors it is in the outer zone where many of the wells are not arranged so that they can be relieved of the pressure of the salt water before testing.

*See Natural Gas map in 20th Annual Report of Department of Geological and Natural Resources of the State of Indiana, 1895.

A COMPARATIVE STATEMENT OF THE ROCK PRESSURE OF THE INDIANA NATURAL GAS FIELD, 1895-6.

	Pounds Pressure.	
	1895.	1896.
Blackford County—		
Hartford City	270	240
Hartford City, five miles west of town	270	245
Delaware County—		
Muncie, three miles north of town	250	230
Royerton	250	232
Daleville, one mile west of town	225	190
Selma	230	213
Selma, three miles north of town	230	218
Albany, three miles north of town	250	230
Grant County—		
Marion, three miles southwest of town	255	244
Marion, three miles southeast of town	260	235
Jonesboro	270	250
Sweetzer	255	246
Swayzee, two miles south of town	260	250
Sims	260	245
Fairmount	270	250
Hamilton County—		
Arcadia, seven miles east of town	235	218
Noblesville, two miles north of town	200	150
Noblesville, nine miles northeast of town	235	210
Hancock County—		
Greenfield, three miles north of town	210	185
Henry County—		
Middletown, five miles east of town	220	175
Howard County—		
Greentown	255	235
Guy	255	235
Sycamore, five miles northeast of town	245	232
West Liberty	255	237
Jay County—		
Camden	150	100
Dunkirk	225	
Redkey, four miles southwest of town	250	235
Madison County—		
Alexandria	247	228
Alexandria, two miles west of town	255	240
Alexandria, one mile north of town	260	240
Anderson, eight miles northeast of town	240	219
Elwood	255	221
Elwood, five miles east of town	255	235
Elwood, five miles northeast of town	255	240
Frankton, two miles south of town	245	220
Gilman	255	240
Orestes	255	238
Perkinsville	230	210
Rush County—		
Carthage	150	120
Tipton County—		
Tipton		270
Madison Township	245	220
Prairie Township	205	
Wild Cat Township	250	238

GAS WELLS.

When considering a natural gas field the condition of the wells is an important item. This is an index of the condition of the field. With proper care, wells limited by unfavorable territorial conditions are frequently serviceable, while with the reverse, wells located in productive territory are sometimes rendered comparatively valueless in a short time. Referring to this field, if it is considered as a whole, it may be said that

the wells are in good condition. However, a few instances have come to my notice where gas companies, manufacturers and individual owners of wells continue to attach consumers and increase the consumption of gas until the wells from overdraught, and the consequent invasion of salt water or stoppage, caused by solid particles collecting in the pores of the gas rock, are useless. Gas companies and owners of wells are fast learning that it is a mistake to turn wells into the line and pay no further attention to them until signs of exhaustion makes it necessary. A little care in estimating the gas consumed and capacity of the wells will reveal the true condition and the proper course with reference to new wells. A productive gas well is valuable property. The natural gas area and the stock of gas are limited. The reservoir has been honoring an enormous draught annually since 1887. The time of complete exhaustion is coming, and all are interested in extending the life of this valuable fuel to the farthest possible limit. To this end the wells should be examined frequently, at least once a month, during the period of heavy consumptions, and the conditions noted. The rock pressure and the pressure of the well when connected with the line should be ascertained, and from these the working pressure. This will aid in determining the necessity for new wells. If salt water makes its appearance in such quantities that it is difficult for the pressure of the gas to raise it, investigate the merits of the various devices that have been invented to separate the gas and water. If small tubing is used, the well once cleaned can be kept so by the aid of a very little gas, much less than is lost by allowing the wells to fill with salt water. When the pressure is strong enough to raise the water in the larger tubing, automatic separators placed at the wells will prevent the water from entering the line, and properly adjusted drips will counteract the evil influence of the water that from any cause has gotten into the line. While any or all of these or other devices may fail to do the work for which they were constructed, the failure often comes from the lack of proper care.

As I have said, the failure of a well may be due to a stoppage of the rock or lack of porosity in the immediate vicinity of the well. In such cases, drilling the well a few feet deeper or the explosion of a torpedo in the Trenton limestone may meet the difficulty. The former has been tried by the Elwood Natural Gas and Oil Co., of Elwood, Ind., and the latter by the Citizens' Gas Co., of Marion, Ind., and the Logansport and Wabash Valley Gas Co., Peru Division, Peru, Ind. While the results have not been uniformly beneficial, in most cases the well has been restored to usefulness for a limited period of time. One experiment by the Citizens' Gas Co., of Marion, is worth especial notice. This well is located two and one-half miles southwest of the city, in productive, though thoroughly drilled territory. It had been drilled four years and was never a large well, though the rock was penetrated the usual depth

for that section of the gas belt. At the time it was "shot" it was apparently exhausted. It had been tubed with two-inch pipe, which was drawn, and sixty quarts of nitro-glycerine exploded in the gas rock. The result far exceeded the most sanguine expectations. It was necessary to retube with three-inch pipe, and one week afterward it was perfectly dry and flowing at the rate of 6,738,000 cubic feet of gas every 24 hours, an extremely large well for this territory, and in fact for this field, at this late date. This is an exceptional case. The rock is probably very dense in the immediate vicinity of the well, and the small pores that did exist were so thoroughly clogged with salt, solid members of the paraffin series, etc., that the gas could not enter the bore.

Natural gas wells must have care if we would realize their full value. If not housed, the tubing and fittings exposed should be kept painted, and the valves, etc., should be kept tight and in working order. New wells should be fitted with nipple and stop-cock, that a pressure gauge may be attached when necessary.

GAS PLANTS.

Generally speaking the gas plants in this field are in a good condition and better prepared to transport, distribute, reduce and regulate the pressure of the gas, to the safety and satisfaction of both consumer and gas company, than at any previous time. But few of the gas plants constructed in the early history of the field were planned or "put in" by practical natural gas engineers. This is especially true of the plants in the smaller towns. More than this, many were constructed hurriedly, during the winter season, and in some cases inferior piping and fitting were used. The time has been when wells in which the packers were not properly adjusted, lead-joint pipe-lines, piping too small for the work to be done, which led to a dangerously high pressure in order that the gas might be distributed, and regulators too small to regulate the pressure of the necessary amount of gas were frequently found.

Time and necessity have forced a changed condition. A more perfect knowledge of the generation and value of natural gas, more care and skill in the adjustment of the tubing and packers in wells and the enforcement of the law regulating the "sinking, safety, maintenance, use and operation of natural gas and oil wells," have practically stopped the waste of gas at the well. True, it requires constant vigilance on the part of the Supervisor and others interested to prevent oil prospectors from allowing wells in the gas territory to stand open. All prospectors are not negligent in these matters; in fact the majority show a disposition to protect the gas territory as well as obey the law, but a few cases have been reported to this department this year wherein it seemed that

the only remedy was the law. However, I am glad to say that in all these, with a little delay, the wells have been properly tubed and packed, or securely plugged, without a prosecution.

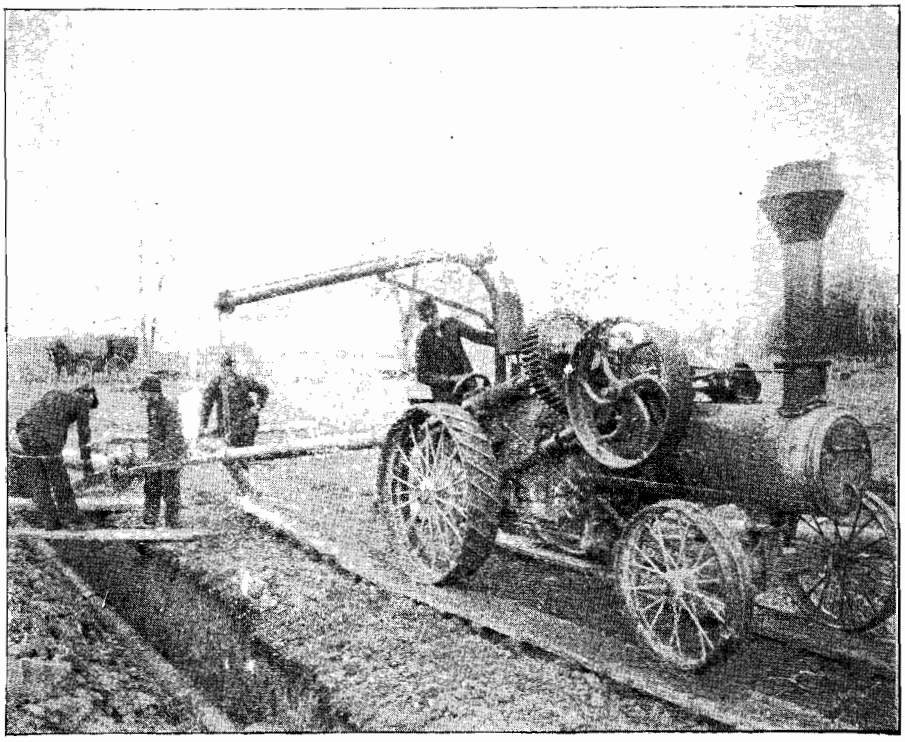
I desire to say, in this connection, that I have no disposition to antagonize or hinder the progress of the oil industry in this State, except in so far as it tends to destroy the natural gas industry. No productive oil wells have been found in high pressure gas territory. Wells drilled in this territory usually result not only in a loss to the

Screwing 8-inch pipe joints by hand.

oil prospectors, but to the gas territory as well, as they are drilled below the salt water horizon. If it is true, as it seems to be, that the major part of this field contains both gas and oil, the reservoirs of which are differentiated, and that upon the exhaustion of the gas the oil will invade its level, there is no excuse for destroying the gas territory to obtain oil.

CONDITION OF PIPE-LINES.

The first pipe-line companies that entered this field seemed to do so without any definite plans or purpose, except to get gas at the least possible cost. As a result, there were many conflicting interests and much money spent without an adequate and permanent return. Two or more lines would enter the same territory, and occasionally wells were drilled, not to exceed forty feet apart. This condition has changed. Conflicting territorial interests are usually adjusted, and the condition of the field, location of the pipe-lines and wells, etc., are taken into consideration by the different companies when plans for extensions are made.



Screwing 8-inch pipe joint by machine.

With but few exceptions the pipe-lines in the State are in good condition. I have reference to the large pipe-lines. Miles of it pass through farms without the least inconvenience to the farmer, the land over and near the line being cultivated and without signs of escaping gas. A number of imperfect gates and fittings, found while inspecting new lines recently, were promptly repaired when notice was given the companies.

Pipe with the most approved joints has taken the place of some of the lead-joint pipe that was laid years ago in this field, and where the pipe has not been changed the joints have been carefully inspected, and in the majority of cases air-tight clamps placed over them. Much of this work has been done during the past year, and the various companies signify their intention to keep at the work, until every defective joint is repaired. Watchfulness and prompt action is the only remedy for this means of waste. These pipe-line leaks along the public highway are not only dangerous to the public, but are wasteful and damaging to the line, and a gas company can ill afford to allow them to go unnoticed.

Reports from every county in the gas belt show that there are near 350 natural gas companies in the State. That does not include the large numbers of factories that control their own fuel supply. A large per cent. of these are companies with one or two wells and a score or more of miles of pipe-line, varying in size from one-half to two inches in diameter. In addition to these hundreds of miles of small lines tributary to the large pipe-lines thread the gas belt, conducting gas to farm houses. These in the past have been the source of great waste. A natural gas leak, however small it is, is not only dangerous, but very damaging to the pipe. The sulphuretted hydrogen contained in the gas is absorbed by the water and oxydized by contact with air to sulphuric acid, which readily attacks the pipe, forming sulphate of iron or copperas. The above acid attacks the pipe to such a degree that it is often eaten entirely through. The gas is not the only loss. I realize how difficult it is to keep these small pipes, lying on top of the ground, subject to a varying temperature, in repair. As with the larger lines, watchfulness and prompt action is the only remedy. A number of companies keep men whose sole duty it is to keep these lines in repair. This is advisable.

As I have said, with but few exceptions, the gas plants of the State are in better condition to give satisfactory service this year, than at any time during the history of the field. I do not mean by this that the supply of gas is more abundant, but at most places it is ample and the facilities to transport and distribute were never better. In a few instances the plants if, not new, have been so thoroughly repaired that they are practically so, being much better than when first constructed, from the fact that the reconstruction has been made with reference to the work to be done. Larger regulators have been used, the necessary high lines and reducing stations have been added, and if satisfactory service is not given this winter, the fault will not be with the gas plant. Nor are the small companies alone in making improvements. The large pipe-line companies are preparing by drilling wells, extending field lines, enlarging the main service lines, and erecting pumping stations to reinforce the field pressure, to give satisfactory service.

While a gas company is largely responsible for the service rendered, it is not wholly so. The consumer is to a certain extent a party. A gas company may have an ample supply of gas and a plant practically perfect, so far as the regulation and distribution of the supply is concerned, and yet render unsatisfactory service to some of its patrons. In order to realize the full heating power of natural gas, it is necessary to mix it with air. As to the proper proportion of air to gas there is a difference of opinion; ten of air to one of gas is not far from correct. If this proportion is to be maintained the pressure of the gas should not vary, for a mixer that will admit gas and air in the correct proportion when the gas is under a twelve-ounce pressure will admit a larger amount of gas if the pressure is increased to sixteen ounces. Ninety-six cubic feet of gas under a pressure of three-tenths of a pound will pass through a No. 7 mixer in one hour, while under one pound pressure one hundred and seventy-nine cubic feet will pass through the same mixer in the same time. It is evident from the above that when a mixer is so adjusted that the gas and air are admitted in the proper proportion, the pressure of the gas should not be changed unless the amount of air admitted is changed to correspond. Referring to this subject, Prof. Elwood Haynes said in my last annual report:* "The volume of air required to burn 100 cubic feet of gas is 1,001.27, or almost exactly ten times the volume of gas consumed. In practice, however, it is advisable to use a little more air than is called for by the formula,† in order to insure perfect combustion. If, however, the mixture can be made perfect it is not advisable to admit too much air, as all surplus air tends to carry away heat which might otherwise be utilized. A good method of regulating the "quality" of a gas flame is to adjust the air supply at the mixer in such a manner that there is just a slight white tip occasionally visible at the end of the flame, and then turn on enough air to cause this to disappear.

It is obvious from the above that unless the mixer is clean and so adjusted that the gas and air are admitted in the proper proportion and a uniform pressure is maintained, that the combustion will not be perfect. The result of incomplete combustion is never satisfactory. That natural gas is used extravagantly by domestic consumers is known by every one that uses it. Its very convenience leads to this. Crude mixers and burners do not allow the full power of the gas to be realized, and with this the temperature of most dwellings is kept above the health limit. With the present system of selling gas it is difficult to change these conditions. The difficulty can be reduced to a minimum, however,

* Utilization of natural gas, p. 204.
† Given in same paper.

if the consumer will see that all mixers and burners are clean and properly adjusted to the gas pressure, and the gas companies that the gas pressure is kept uniform at the point of comsumption.

THE FUTURE OF THE INDIANA FIELD.

In so far as they serve to light the future, the present condition of the Indiana natural gas field and its past history are questions in which much interest is being manifested by all classes of consumers, as well as the gas companies of the State. All are anxious about the future of this fuel and its increased cost, caused by the drilling of new wells, the extension of pipe-lines, etc., necessary to maintain our supply, stimulates this anxiety, as well as an appreciation of its benefits. Factories, public buildings, residences and in fact all classes of buildings, built during the last ten years, in which a heating power is required, have, at more or less expense, been fitted for gas. And while the return to wood or coal would cause great inconvenience in the way of changes and the remodeling of heating apparatus, it is not beyond a future possibility. Nearly all agree that the supply will finally be exhausted, but when, is the question. We can examine this field under the light of the finished history of the Findlay field, but when we consider the conditions and limitations surrounding it and not found in this field, and *vice versa*, we at once see that an answer based upon the most trustworthy data obtainable is little more than a guess. Those who have ventured an answer have been compelled to revise it from time to time, as unforeseen conditions arise. It can not be said, however, that because the life of natural gas is a subject of speculation, that all phases of the question are thus. Science has settled some questions beyond a doubt. That natural gas has its origin through the decomposition of organic matter contained in the rocks; that it is a stored product, and that nature has made no provision for a renewal of the supply, are conclusions that are not questioned by students of the subject.

The life of this field, then, is to be determined by the extent of the reservoir, or supply of gas, and consumption. Regarding the former, its capacity has not been determined, nor can it be. The porous rock forming the reservoir is known to be but a few inches thick in some localities, while in others it varies from twenty to thirty feet. We have no means of estimating the capacity of this irregular mass of gas rock. Referring to this subject, Prof. S. S. Gorby, Ex-State Geologist, says:* "Confined within its reservoir of rock, the gas is compressed to an enormous extent. There is no means of determining the capacity of the interstices of a cubic foot of porous rock that forms the gas reservoir. When the exact

*Sixteenth Annual Report of the Dept. of Geology and Natural Resources of Indiana, 1888, p. 200.

limits of the gas area are known, and when the average thickness of the rock is known, the capacity of a gas reservoir may be estimated to an approximate degree, but it will never be possible to estimate to any satisfactory extent the capacity of the interstices that contain the gas. If it was known just how many cubic inches of gas in its compressed state there are in a cubic foot of porous rock, and if it was known, too, just how many cubic feet of gas those cubic inches are equal to, reduced to atmospheric pressure, then we could determine approximately how many thousand million of cubic feet of gas there are in a reservoir."

If we do not know the extent of the reservoir or amount of gas stored therein, and do know that there is a definite limited stock, then the future of the field is uncertain, and will be governed by the way it is used.

Professor Edward Orton refers to the subject as follows:* "That the gas and the oil are stored products, accumulated in rocks of suitable structure to serve as reservoirs, or, in other words, that we are drawing upon a definite stock of this substance, is the only rational view to be taken of the facts involved. There was in the Findlay field originally a vast but still not an incalculable amount of gas, either dry or held in and permeating the oil that accompanies it. Upon this stock the wells are drawing. From it a given number of millions of cubic feet can be used for a given number of years, but when once exhausted there is no more possibility of its renewal in the reservoir than there is of the growth of coal in mines that have been worked out. It is in this light that the waste of these priceless accumulations ought to be regarded."

From what has been said the duty of every gas company, consumer and person employed in the natural gas industry is plain. If the life of this gaseous fuel depends upon the way it is used, then let us practice an economy commensurate with its value, and stop all waste. Notwithstanding the extravagant use and vandal-like waste in the past, no one will deny that much can be done to extend the life of gas by a strict observation of the above in the future.

Those not familiar with the gas field probably consider it a waste of time and space for me to argue at this time the necessity of husbanding the supply of gas; and, true, it seems reasonable to suppose that every one interested would see the necessity of it, and govern himself accordingly. I am sorry to say that such is not the case. While the constant agitation of the matter in the published reports from this department, and the personal efforts made by the Supervisor and other interested parties who know the necessity and importance of prompt action has done much good, there is still room for a vast improvement.

* Eighth Annual Report of the United States Geological Survey, 1889, p. 612.

In so far as natural gas has stimulated the manufacturing industry, and influenced capital to invest in this State, thereby increasing the wealth of the State, it has benefited every taxpayer and citizen. Those most directly interested, however, are residents of the gas belt, gas companies, manufacturers, farmers, laborers and domestic consumers. It is to these we must look for aid in husbanding the supply of gas, and in creating a public sentiment against the prodigal use of it.

Gas companies can do much toward protecting the natural gas industry, not only by preventing waste at the wells, along the line, etc., but by inspecting the burners, mixers and other devices used by their consumers and suggesting such changes in the same as economy and safety require; also, by properly regulating the pressure of the gas at the point of consumption, to the end that the maximum amount of heat may be obtained from the gas used.

It would not be just to say that all manufacturers use natural gas extravagantly, but an examination will convince any one that a majority use more for both fuel and light than is necessary. In many instances the burners, mixers, etc., are so unscientific and ill-arranged that perfect combustion is not possible. The full heating power of the gas is not realized and more fuel is used than would otherwise be necessary.

Natural gas as an illuminant is not a success. It produces a very poor light, and when its value as a fuel and the amount of gas necessary to make even a passable light is considered, it is expensive. Many of the larger manufacturers, realizing this, are substituting other light for it. That it is convenient for this purpose, when used as a fuel, is the most that can be said in its favor. If it is used, however, I am sure that it is quite unnecessary and wasteful to allow large torches to burn night and day in all departments of the factory, whether operating or not.

As I have said all manufacturers are not wasteful in using this gaseous fuel. There are a few, and the number is increasing, that fully appreciate its value and use it accordingly. I have visited a large number of factories this year, and all suggestions made by me regarding the economical use of gas have been received in the same spirit in which they were given, and in most cases acted upon. It is my purpose to visit all the factories using gas as soon as my duties will permit.

If it could have been possible for us to keep the enormous fuel supply that was stored in the rock underlying this section of the State within the borders of the gas belt, the result would be far different from what it will be, judging from present indications. It is impossible to place the limit on the time for which the supply would have been adequate for the local consumption, but cities in adjoining territory, knowing the advantages possessed by it, organized companies and invaded the field; and while the result will be a comparatively speedy exhaustion of the field, it will also be a speedy remuneration to the land owner for the rights

and privileges granted the gas companies. During the past year the expenses of the various gas companies on account of rentals, gas privileges, labor, etc., was above $550,000. Of this amount about $300,000 was paid direct to the farmers. This does not include cost of pumping stations or office expenses of the larger companies. It is plain that the residents of cities are not the only beneficiaries of the natural gas industry. Many land owners are receiving annual gas well rentals equal to two and one-half dollars per acre for their entire farm, and some are receiving five, that is, $400 annually from an eighty acre farm. In addition to the above, free gas for domestic purposes is usually included in the lease.

Taking into consideration the fact that the natural gas industry does not interfere with the use of the land for farming purposes in the least, there seems to be good reasons why farmers should aid the efforts that are being made to prevent such waste in the future as has been allowed in the past. When by care and extra expense the life of a well is extended one year, the landowner is a beneficiary to the extent of the annual rental. It is from this standpoint and the general welfare of the gas belt and State that the farmer should consider all efforts to husband the gas supply.

Of the three classes of natural gas consumers; pipe-line cities, fac tories and local domestic, the former will first feel the exhaustion of the field. When gas has to pass through a considerable amount of pipe before it reaches the consumer, the initial pressure is an important item. It is affected by friction against the walls of the pipe in the same manner as is water or any other liquids. The loss in pressure is goverened by the size of the pipe, length of line, velocity of flow, condition of the gas, etc. Added to the above there is often an unnecessary loss of pressure by reason of numerous bends and elbows in the pipe and leakage. By removing, as far as possible, these unnecessary conditions, the loss will be reduced to a minimum; but even then the back pressure in the pipe will finally overcome the initial pressure. Under the most favorable conditions, the distance that natural gas can be piped is limited, unless pumps be used. While the loss of pressure by friction in any given line can be ascertained if all the conditions are known, they are so many and varied in this field and the effect of each is so difficult to ascertain that results of calculations on the subject are not very satisfactory. Each line is surrounded by conditions differing to some extent from those of any other line, and the loss of pressure in a given line does not indicate what it is in other lines of similar dimensions. Examinations of a number of lines show that the loss of pressure during the period of heaviest consumption is from two to six pounds to the mile, owing to the consumption along the route of the line and the other conditions referred to above.

THE MANUFACTURING INTERESTS OF THE GAS BELT.

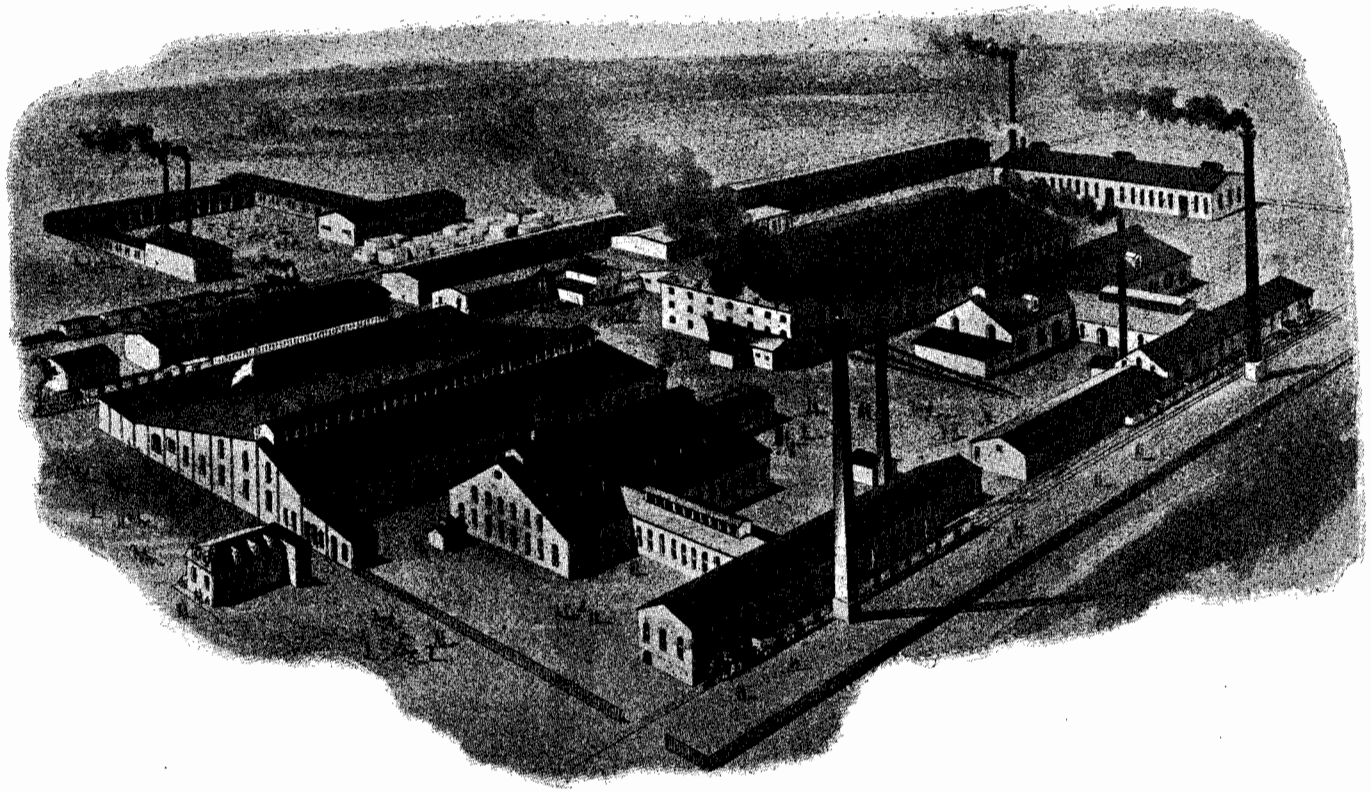
For reasons previously stated, the gas belt has become the manufacturing center of the State, and the many evidences of a decrease in the gas supply naturally encourages speculation regarding the future of these industries. While every taxpayer is interested in this question, residents of the gas belt are especially so. A sufficient cause for this is found in the increase of wealth and volume of business in this section of the State since the discovery of gas. I have endeavored during the past year to familiarize myself with the condition of the fuel supply of the factories located in the gas belt on account of natural gas. While a change of fuel will be necessary in the future, and no person knows this better than the manufacturers, there is no cause for immediate alarm. Manufacturers know and appreciate the value of natural gas, and are providing for the future as far as possible. The larger factories, located near cities where the field shows signs of exhaustion, have pipe lines and sufficient territory to protect their interests. Others located where the consumption for other purposes is light are drawing from wells in the vicinity of the factory, two hundred feet of pipe in some instances being sufficient. True, a majority of the first wells drilled show signs of exhaustion, but in many cases the territory is only partially developed, and the new wells are usually productive. Any signs of a shortage in the fuel supply causes much anxiety regarding its future on the part of the manufacturers, and this is usually followed by more care and economy in its use. Further inquiry shows that other fuels can be used, without serious inconvenience, to supplement the supply of gas where it fails to come to the full requirements of the manufacturing plants.

Of course the chief reason for the location of factories in this section of the State during the last nine years are the advantages possessed by this fuel, but evidence is present that the proximity to the markets of the country and the splendid railroad facilities possessed by this section were considered. And, while it is true that some manufacturers who have outlived a less productive gas field are apprehensive concerning the future, they are disposed to find another fuel in case it is necessary, rather than a new location. Taking into consideration the present condition of the field, the proximity to the Indiana coal field and its railroad connection with the gas field, it seems that a majority of the manufacturing industries of the gas belt are permanently located.

The gas used for domestic purposes is a small per cent. of the entire consumption, and for obvious reasons it will be used longer for this purpose than any other. When the supply is exhausted, so far as the larger consumers are concerned, wells apparently worthless will continue to supply gas sufficient for domestic consumption, and a redrilling of abandoned territory is not beyond the future possibilities. Fairly productive

wells, though short lived when turned into a factory line, have been found in abandoned territory. Doubtless they would have been more satisfactory if used for domestic purposes only. A visit to those sections of the field where the supply has never been large, and the rock pressure is low, will convince any one that very small wells are used and appreciated where larger wells are not to be had.

The territory in which natural gas has been found is comparatively small, but its influence extends far beyond the limits of the field. Wherever the products of the gas belt factories are sold, there you will find those who are anxious about the life of this gaseous fuel. Nor is it probable that its influence will cease to be felt when the supply is exhausted; for the use of it by practical fuel consumers and the knowledge of its superiority as a heating power gained thereby, has so revolutionized the construction and arrangements of manufacturing plants and modified manufacturing methods to such an extent, that it is probable that better results will be obtained from other fuels in the future, and it may open the way to the use of fuels heretofore not available. Natural gas is a cleanly fuel. It is economical and convenient, and its superiority as a fuel is best illustrated in the improved quality of the product of the gas belt manufactories.



Hartford City Glass Company's Factory, Hartford City, Indiana. A "gas belt" factory employing 600 men; 120 blowers; monthly pay-roll, $50,000; annual capacity, 400,000 boxes.